STARVED CIRCUIT AMPLIFIER

Oversized load resistor reduces both plate voltage and current, yet gives gain of almost 2000 times

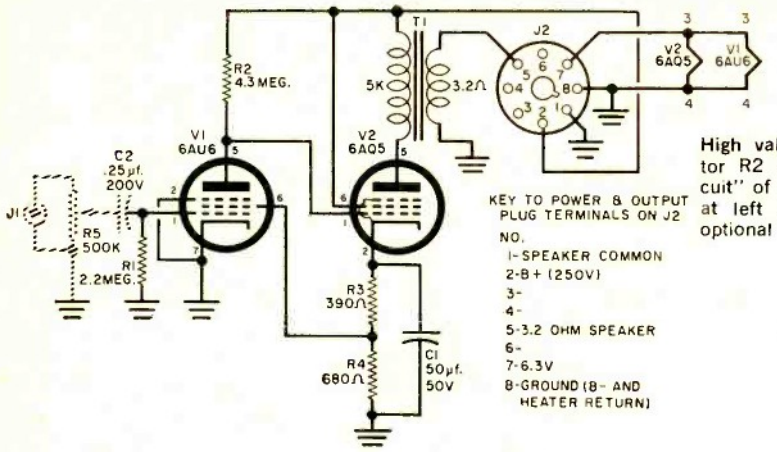
By HOWARD BURGESS

HAVE you ever put an amplifier on a starvation diet? It's almost unbelievable how much gain an ordinary tube can turn out when it gets really "hungry." Special circuits, sometimes known as "starved circuits" because of their very low plate voltages, have been designed for just this purpose and are among the oddities of electronics.

Few other types of amplifier circuits can do so much with so few parts. For example, a two-tube audio amplifier using "starved" circuitry can give voltage gains in excess of 50,000 with only 4 resistors and 2 capacitors; this probably qualifies it as one of today's best bargains. The little starved-circuit amplifier to be described here will give you a good idea of what can be done.

Theory. Those who like to know the "why" before they build should start by

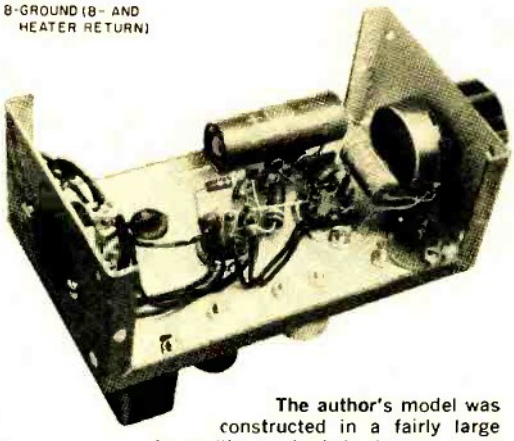
Completed unit has high gain but limited frequency response, a useful combination for signal tracing and speech amplification.



High value of plate load resistor R2 is key to "starved circuit" of V1. Shaded components at left in schematic comprise optional gain control circuit.

PARTS LIST

C1—50-μf., 50-volt electrolytic capacitor
C2—0.25-μf., 200-volt paper capacitor
J1—Phono jack
R1—2.2-megohm, ½-watt resistor
R2—4.3-megohm, ½-watt resistor
R3—390-ohm, 1-watt resistor
R4—680-ohm, 1-watt resistor
R5—500,000-ohm potentiometer, audio taper
T1—Output transformer; primary, 5000 ohms; secondary, 3.2 ohms (Knight 62G064 or equivalent)
V1—6AU6 tube
V2—6AQ5 tube
1—5¼" x 3" x 2⅛" aluminum box (Bud CU-3006A or equivalent)
Misc.—Hardware, tube sockets, etc.



The author's model was constructed in a fairly large box, with standard-sized components Your version can be smaller, if you wish.

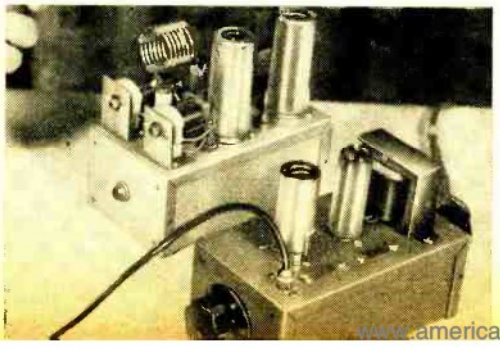
looking at the data sheets for a 6AU6 pentode. This tube gives a gain of about 300 with a 250-volt plate supply; and if the voltage is reduced to 100, the gain may fall as low as 110. If the screen and plate voltages are reduced to about 15 volts, however, the gain may go up to well over 2000 under the right circuit conditions.

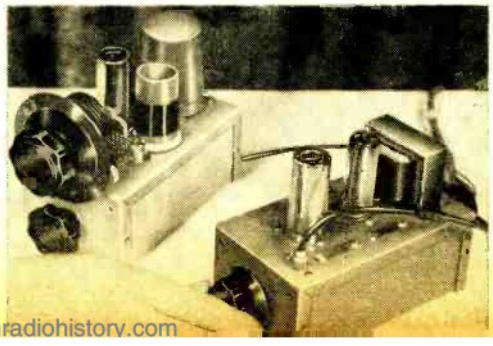
One of the secrets of achieving this high gain is the use of a very large plate resistor. The signal voltage developed across a 10-megohm plate resistor, for instance, becomes quite high for even a very small plate current.

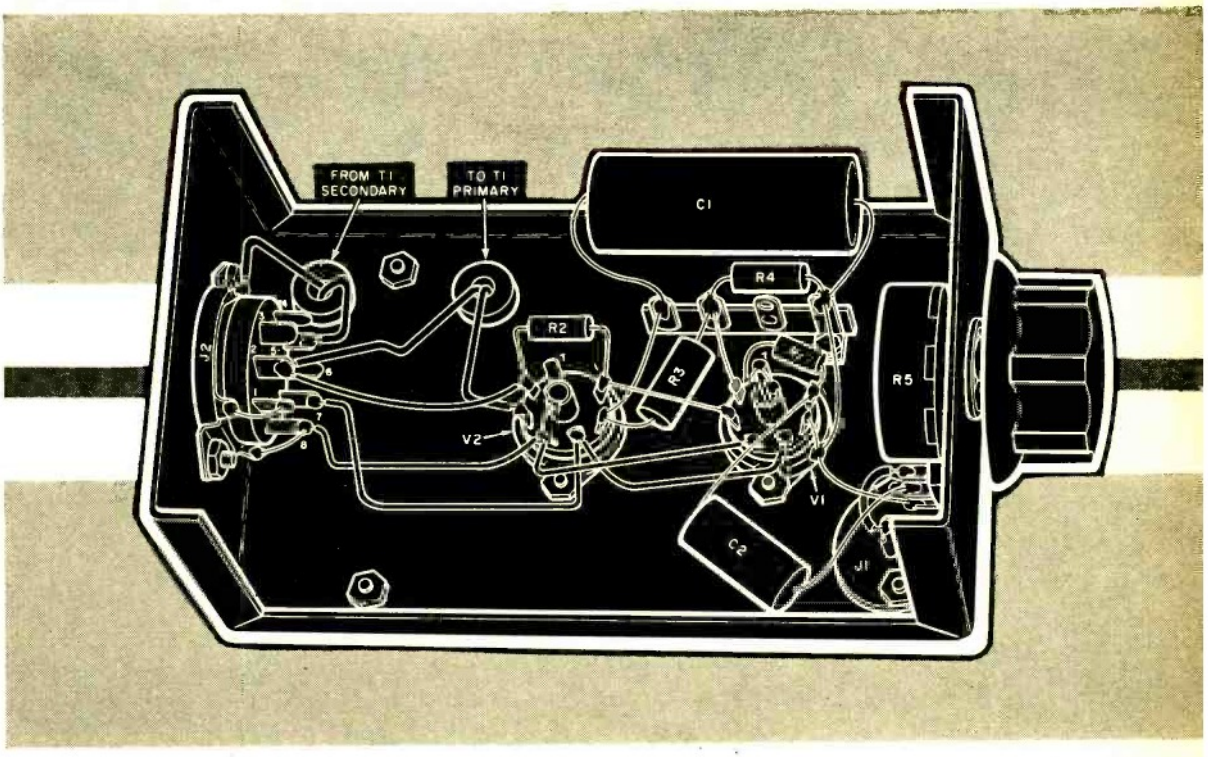
Starved circuits should not be confused with circuits using 12-volt plate tubes, by the way. The gain of a true starved circuit depends on the use of several hundred volts dropped across the plate load resistor.

The Circuit. The schematic diagram shows the extreme simplicity which can be designed into a starved-circuit amp-

Two possible applications for starved circuit amplifier: modulating low-powered transmitter (left, below); and amplifying output of small crystal receiver (right).







lifier. Almost any of the common tubes can be used if slight changes in circuit values are made; some tubes, of course, will give more gain than others. Two very common types are used here—the 6AU6 pentode (*V1*) and the 6AQ5 beam power audio tube (*V2*).

One of the main points of interest in this circuit is the direct coupling from the plate of the 6AU6 to the control grid of the 6AQ5. It is possible to eliminate the usual coupling capacitor and grid resistor because the plate of *V1* is only about 17 volts above ground. The grid of *V2* has a comfortable value of negative bias—even though it is tied to the plate of *V1*—because *V2's* cathode is about 32 volts above ground.

It was found by experiment that *V1* works very well with about 20 volts on its screen. This voltage could have been taken from the plate supply, in the ordinary way, with a dropping resistor and bypass capacitor. Instead, however, the screen grid is tied to a point on the cathode resistance of *V2* about 20 volts above ground—so no bypass capacitor is needed for the screen grid.

The schematic diagram shows two fixed resistors (*R3* and *R4*) with a total value of 1070 ohms in the cathode circuit of *V2*. If you like to experiment however, you might replace these resistors with a 1000-ohm, 2-watt potentiometer. The screen grid of *V1* could be connected to the slider arm. Adjusting this arm would vary the value of the screen voltage on *V1*, which in turn could be used to control the amount of plate current in *V2*.

Control grid bias for *V1* is furnished by the so-called "contact" potential which is developed across resistor *R1*. This allows the cathode of *V1* to be grounded, eliminating another resistor and bypass capacitor which are usually necessary.

Potentiometer *R5* and capacitor *C2* constitute an optional gain control circuit; the capacitor must be used even if the gain control circuit is not, in order to avoid loss of bias on *V1*.

We have now "thrown away" almost as many resistors and capacitors as we have kept. With fewer components, the amplifier circuit is easier to manipulate. It would be no problem now for the ex-

(*Continued on page* 115)

Starved Circuit Amplifier

(*Continued from page 71*)

perimentally minded builder to alter the characteristics of the unit with a few simple resistor changes.

Frequency Response. Of course, no amplifier offers everything, and starved circuit units are no exception. Though these amplifiers are long on gain, they are somewhat short on high-frequency response.

In this particular circuit, the gain is between 25,000 and 30,000, but the upper frequency limit is between 2500 and 3000 cycles. Although a frequency range of 50-2500 cycles may not appeal to the hi-fi enthusiast, it covers the most common voice frequencies and is ideal for communications or intercom work. Under certain circuit conditions it will be found that the audio level is almost self-limiting, and no clipping is introduced.

The upper frequency limit of the amplifier can be increased by reducing the resistance of *R2*, though the gain will suffer. Since direct coupling is used between the tubes, just about the only limits to the *low-frequency* response are the sizes of *C1* and *C2* and the characteristics of the output transformer (*T1*).

Uses. The starved-circuit amplifier can be used as a very sensitive signal tracer or voice amplifier. It has sufficient gain to operate from a low-level microphone and can serve as a low-power modulator, a driver for a higher power modulator, or an intercom amplifier. Since the circuit is adaptable to miniaturization, many other uses will suggest themselves. The minimum of construction involved won't upset anybody's time or parts budget. -30-